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# Population Aging and Global Capital Flows in a Parallel Universe

ROBIN BROOKS*

*This paper uses a multiregion overlapping generations model with perfect capital mobility to simulate the general equilibrium effects of projected population trends on international capital flows. It finds that retirement saving by aging baby boomers will raise the supply of capital substantially above investment in both the European Union and North America, causing both regions to export large amounts of capital to Africa, Latin America, and other emerging markets in the years ahead. Beyond 2010, however, baby boomers in the European Union and North America will dissave in retirement, causing both regions to become capital importers. This shift will be financed by capital flows from Latin America and other emerging markets, while Africa will remain dependent on foreign capital for the foreseeable future because of continued high population growth. Despite severe population aging, Japan is predicted to remain a substantial capital exporter beyond 2030.* [JEL E21, F21]

The world population has aged significantly in the past 50 years, a reflection of declining fertility rates and rising life expectancy in many countries. However, there are significant differences across regions in the pace and timing of this transition, especially between fast-aging industrial nations and some developing countries, where population growth has remained high. This paper explores the role of these differences as a long-run determinant of international capital flows.

*Robin Brooks is an Economist in the Financial Studies Division of the Research Department. Special thanks are due to Richard Hemming for the main idea behind this paper, to examine the global dimension of population aging using a model of large open economies. The author is also grateful to Orazio Attanasio, Richard Disney, Robert Flood, Peter Isard, Eswar Prasad, and two anonymous referees for many helpful comments, and Sheila Kinsella for preparing this paper for publication.

It develops a multiregion overlapping generations (OLG) model with perfect capital mobility, in which exogenous population and productivity growth are allowed to differ across regions and over time. The model is calibrated to match the evolution of income per capita levels across developed and developing countries and used to simulate the general equilibrium effects of historical and projected population trends on regional saving-investment balances. The basic effects of demographic change in this setting are intuitive. For example, a fast-aging region will observe a surge in saving as a large group of workers prepares to retire, while investment demand will fall, a reflection of the declining workforce. Assuming perfect capital mobility, this mismatch will generate capital outflows to regions with higher population growth, until the return on capital is equalized across regions.

The paper makes several advances relative to the literature. It builds a Diamond (1965)-type model, in which agents move from dependent childhood through two periods of working age to retirement. This setup generates a life cycle profile for saving consistent with evidence from household survey data. Young workers save hardly at all, constrained by youth dependency effects. Instead, retirement saving happens late in life, between the ages of 40 and 60. Because the paper explicitly models childhood and retirement, it captures aggregate saving effects from changes in both youth and old-age dependency, which have been shown to be empirically important.[1] The framework also allows for the possibility that lower youth dependency from declining fertility, an important feature across developed countries, may offset the adverse effects on aggregate saving from having many old people dissave in retirement.[2] In addition, the model allows for possible effects from changes in population growth on labor supply. This is important because declining fertility in industrial countries has been associated with rising labor force participation rates among women, a development likely to spread to developing nations in coming years. Finally, this paper is more comprehensive than existing work, calibrating the model to have eight regions that divide up the world population along geographical lines and stages of development: North America, the European Union, Japan, Latin America and the Caribbean, China, Africa, the former Soviet Union (FSU) countries, and a region for the rest of the world.[3]

The results suggest that differences in population trends around the world have been an important determinant of international capital flows over the postwar period. They explain the emergence as capital exporters of the European

[1] Higgins and Williamson (1996) find that much of the rise in Asian savings rates since the 1960s can be explained in terms of the decline in youth dependency. Higgins (1998) finds that increases in youth and old-age dependency are associated with lower saving, using data for a large cross section of countries. He also finds evidence of differential effects on saving and investment, and thus a role for demography in determining the current account balance.

[2] Börsch-Supan, Ludwig, and Winter (2001) explore the effects of population aging on international capital flows, using a Diamond-type model without children. Attanasio and Violante (2000) use a similar framework, although their model incorporates mortality risk, which allows them to simulate the saving effects of changes in fertility and life expectancy.

[3] Attanasio and Violante (2000) present a model of two open economies, one calibrated to match a region representing North America plus Europe, the other calibrated to represent Latin America. Börsch-Supan, Ludwig, and Winter (2001) focus on Germany and the Organization for Economic Cooperation and Development (OECD).

Union (EU) countries and Japan, where aging populations have begun saving for retirement; the deterioration of the current account of North America, where population aging is less pronounced; and the persistent dependence on foreign capital in Africa, Latin America, and emerging Asia, where population growth is still high. The results also suggest that the aging of the baby boomers will raise saving relative to investment in both the EU and the United States in coming years, causing both regions to export large amounts of capital to Africa, Latin America, and other emerging markets. Beyond 2020, however, dissaving by the baby boomers in retirement will be associated with large current account deficits in both regions. This shift will be financed by capital flows from Latin America, and other emerging markets, though Africa will remain dependent on foreign capital because of continued high population growth. Despite the most severe record of population aging, Japan is predicted to remain a substantial capital exporter until about 2040, though at a declining rate. This is because the model generates large current account deficits for Japan in the 1950s and 1960s, a reflection of its rapid postwar recovery, and predicts that this borrowing will be repaid through future current account surpluses.

These results are subject to several caveats. First, the model makes the critical assumption that capital is perfectly mobile, while labor is not. Introducing labor mobility would add an additional mechanism to arbitrage away regional differences in productivity and population growth, so that the magnitude of international capital flows would shrink, other things being equal. Other factors also contribute to capital flows being too large. Workers saving for retirement are indifferent between holding North American or African capital, for example, because the model fails to control for differences in risk.[4] Second, the model abstracts from public sector pension systems and thus fails to capture the possibility that, if current benefit structures are upheld, payroll taxes across industrial countries will have to rise to finance the retirement of the baby boomers. This could crowd out private capital formation to such an extent that the return on capital might actually rise in coming years, causing capital to flow from developing to industrial countries, rather than the other way around. In a framework where rising payroll taxes crowd out private capital formation, Kotlikoff, Smetters, and Walliser (2001) show that population aging actually causes the rate of return on capital in the United States to rise by 100 basis points by 2030. This paper forecasts that the worldwide return on capital will fall by about 100 basis points over the same period. Its results are therefore clearly sensitive to the omission of social security. Third, the model presents a stylized representation of the life cycle, which ignores intermediate saving goals—for example, college tuition for dependent offspring—and intergenerational bequests. Adding these features would alter saving behavior over the life cycle, changing the link between aggregate saving and demographic dynamics.

[4] Adding uncertainty to the model would allow capital in emerging markets to be riskier than in industrial countries. Such an extension would generate risk premiums such that risk-adjusted returns across regions are equalized. Lucas (1990) argues that adjusting for lower education in the developing world would reduce the scale of international capital flows. In the context of the model, this would involve scaling down effective labor supplies in emerging markets, thereby bringing their capital-labor ratios up toward those in industrial economies.

There are several motivations for this paper. For the developing regions around the world, understanding the implications of current and projected population trends is important. The labor force in Latin America, for example, is projected to expand significantly in the years ahead, causing some to argue that the region is about to see higher saving rates and faster capital accumulation. Does this mean that its past and current reliance on foreign capital can be explained in terms of high population growth and is therefore consistent with an important long-run fundamental? And looking to industrial countries, is the persistent current account surplus in the case of Japan a reflection of its rapidly aging population? What of the similarly persistent current account deficit of the United States? This paper addresses these questions in a framework that effectively models international capital flows as a function of long-run fundamentals and therefore provides an important counterpart to a growing literature on the short-run determinants of capital flows. Its results suggest the following. For Latin America, the model generates an average current account deficit of about 2.5 percent of GDP over the past 20 years, very close to the actual deficit of 2.3 percent, an indication that the region's dependence on external capital is in line with past differentials in productivity and population growth. The model generates an average current account surplus over the past 20 years of 3.7 percent of GDP for Japan. Compared with an actual surplus of 2.4 percent, this is perhaps an indication that Japan has been constrained in its ability to export capital.[5] For North America, the model generates an average current account deficit of 0.5 percent of GDP for the past 20 years. Compared with an actual deficit of 1.9 percent, this is strong evidence that the current account deficit of the United States is substantially out of line with long-run fundamentals.

Although the model abstracts from public pension systems, an additional motivation for the paper is the current debate over reforming social security. The model corresponds to a setting where pay as you go pension systems have been fully privatized and shows that, even in the absence of the difficult transitional issues relating to the financing of social security reform, projected population trends have important wage and return effects. It also complements the existing literature on pension reform, which uses mostly closed economy models, showing that open economy effects from nonsynchronized population movements are an important addition to the debate on pension reform.[6]

## I. Historical and Projected Population Trends

This section discusses past and future population trends, focusing on differences in population structure around the world. Figure 1 plots youth dependency ratios, calculated as the ratio of the population 0 to 14 to the number of individuals aged

[5] In a recent article in the *Financial Times,* Jeffrey Sachs (2001) argues that fiscal stimulus has been ineffective in generating a domestic-demand-led recovery in Japan since aging households, nervous at the widening budget deficit, simply increase their saving. Instead, he claims that Japan has a structural current account (and trade) surplus and should therefore be allowed to export its way out of recession, something that has been prevented by explicit trade barriers and implicit political threats from the United States and Europe.

[6] For closed economy models, see for example Auerbach and Kotlikoff (1987) and Brooks (2002).

15 to 64, from 1950 through 2150.[7] It shows that there is a wide dispersion in past and projected fertility trends. Among today's industrial regions, the EU had the lowest youth dependency ratio in 1950, at 37 percent, followed by North America with 42 percent and the FSU region with 47 percent. In contrast, Japan had a youth dependency ratio of 59 percent in 1950. Its youth dependency burden was therefore closer to less-developed regions, such as China at 54 percent and the ROW region at 65 percent. Africa and Latin America are at the end of the spectrum. Youth dependency ratios were 78 and 72 percent, respectively, in 1950.

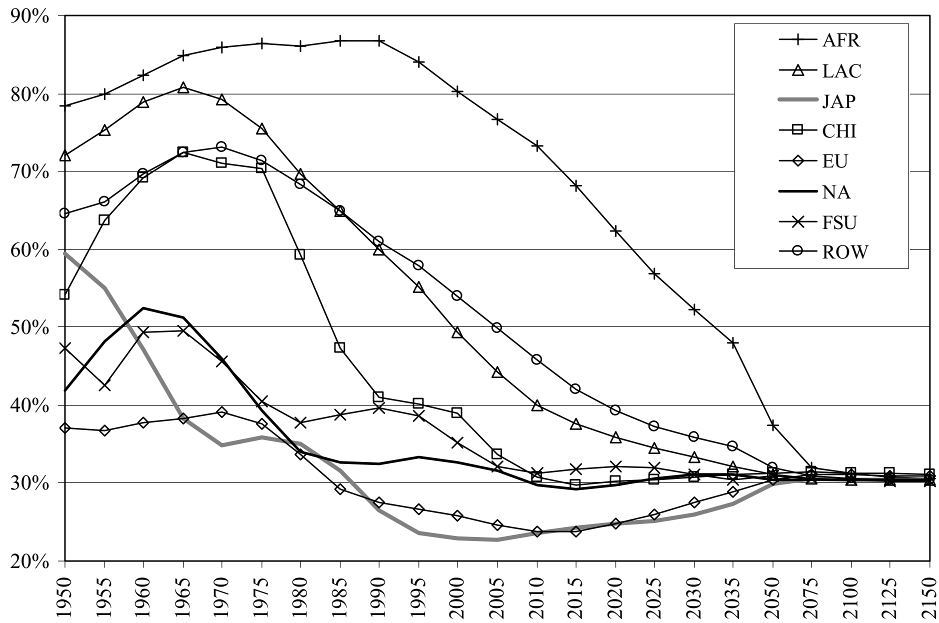
Since 1950 these regions have undergone very different fertility trends. The EU, the FSU, and North America experienced a postwar baby boom, causing youth dependency to rise in the 1960s and 1970s. This phenomenon was most pronounced in North America, where youth dependency rose to a peak of 52 percent in 1960, while it was more subdued in the EU where youth dependency increased only slightly, peaking at 39 percent in 1970. Subsequently, both regions experienced a rapid decline in fertility and now have youth dependency ratios near 30 percent, close to their projected long-run levels. In contrast, fertility rates in Japan have fallen steadily since 1950 and its youth dependency is currently significantly below the projected long-run average. In less-developed regions, the picture is quite different. Youth dependency ratios continued to rise into the 1980s in China, Latin America, and the ROW region, but have since begun to decline. Only Africa appears stuck in a high fertility equilibrium. Its ratio of youth dependency is 80 percent in 2000, about the same level as in 1950.

Figure 1 illustrates an important underlying assumption of the World Bank population data, which are used to generate these ratios. In the long run, the forecast assumes that population growth will converge across regions. As a result, youth dependency ratios around the world converge at 30 percent by 2075, for population growth near zero. Though this feature of the projections is better interpreted as an equilibrium condition, rather than forecast, it is actually helpful in the context of the model. This is because in steady state the assumption of perfect capital mobility requires that the rates of return, and hence population growth, be equalized across regions.

Figure 2 plots old-age dependency ratios, calculated as the ratio of those 65 and older to the number of individuals aged 15 to 64, from 1950 through 2150. It underscores the severity of population aging in Japan, where the old-age dependency ratio has increased from 8 percent in 1950 to a current level of 24 percent, about the same level as in the EU. In coming years, however, old-age dependency in Japan is projected to accelerate substantially and will reach the highest level around the world, at 53 percent, in 2050. In contrast, population aging in the EU and North America is more sedate and is driven by the aging of the baby boomers. Old-age dependency

[7] Regions are denoted as North America (NA), consisting of Canada and the United States, the European Union (EU) made up of its 15 member countries, Japan (JAP), Latin America and the Caribbean (LAC), China and Taiwan (CHI), Africa (AFR), the former Soviet Union countries (FSU), and a region for the population in the rest of the world (ROW). From 1950 to 1990 the data are taken from the United Nations "World Population Prospects: The 1992 Revision," which provides age distribution data in five-year age groups for a large cross section of countries. Data from 1995 onward are constructed using country-specific cohort growth rates, for the same five-year age groups, from the World Bank "World Population Projections: The 1994–95 Edition," using the United Nations data as a base. This splice is made because the United Nations projections extend only to 2025, while the World Bank data go back only to 1990. In 1990, the base year for the projections used in this paper, the age distribution data from both sources are very similar.

Figure 1. Youth Dependency Ratios, (0–14)/(15–64)

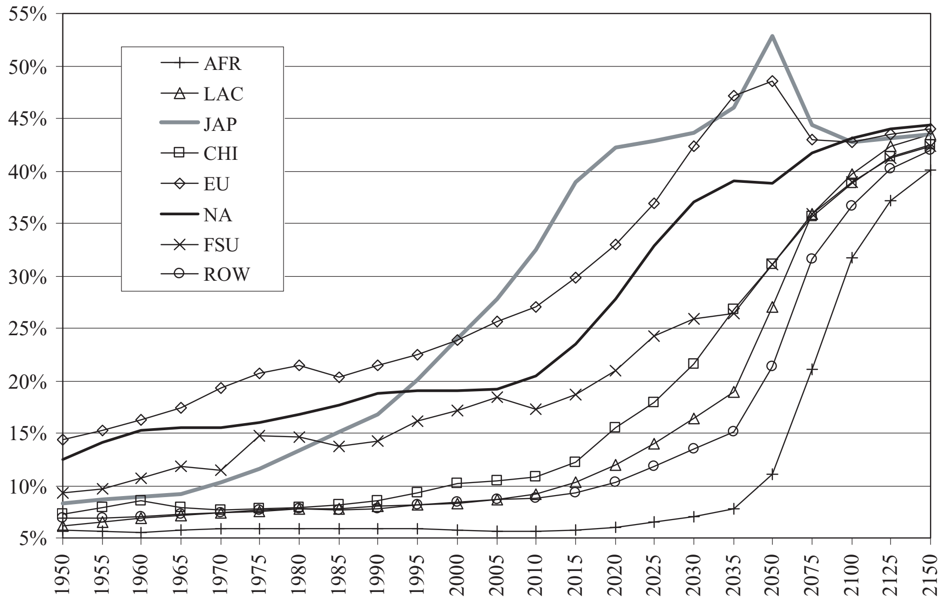



Notes: AFR = Africa; LAC = Latin American countries; JAP = Japan; CHI = People's Republic of China; EU = European Union region; NA = North America; FSU = countries of the former Soviet Union; and ROW = the rest of the world.

ratios in both regions turn up sharply after 2010, when large numbers of the baby boom generation will begin to retire. In the EU this ratio peaks in 2050 at 49 percent, when it measures only 39 percent in North America. Among the industrial regions, therefore, the aging process in North America is comparatively mild. Turning to emerging markets, the old-age dependency ratio turns up sharply in China beyond 2015, a reflection of its policies to reduce population growth, while a sharp upturn is projected for Latin America in 2050. In Africa, old-age dependency is forecast to remain below 10 percent until 2050. Thereafter, the equilibrium condition that population growth be zero across regions drives its ratio of old-age dependency to about the same level as in other regions.

In summary, population aging is projected to be most severe in Japan in coming decades, the result of a dramatic decline in fertility after World War II, which will reduce the number of workers to retirees below anywhere else in the world. In contrast, forecast population trends are more favorable in the EU and North America, where the aging of the baby boomers will raise old-age dependency ratios beyond 2010. Among the developing regions, China will age most rapidly, a reflection of its "one child" policy, while Latin America is projected to have a relatively stable retiree to worker ratio until 2050. In contrast, Africa is projected to remain in a high-fertility equilibrium even beyond that point. These differences in population trends are important in the context of the model, because they imply different implicit rate of return on capital across regions. Under the assumption of perfect capital mobility, international capital flows will then equalize the returns around the world.

Figure 2. Old-Age Dependency Ratios, 65+/(15–64)



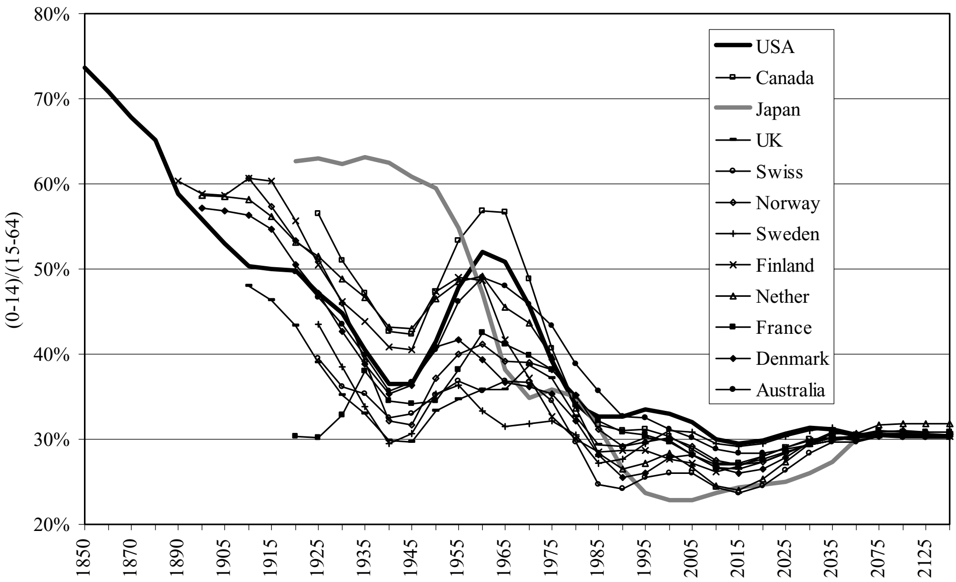

Notes: AFR = Africa; LAC = Latin American countries; JAP = Japan; CHI = People's Republic of China; EU = European Union region; NA = North America; FSU = countries of the former Soviet Union; and ROW = the rest of the world.

As these data suggest, there are substantial differences across regions in population structure even in 1950, when the EU countries, Japan, and North America were on average older than today's less-developed regions. This link between economic development and demographics suggests that the global transition to lower fertility and mortality predates 1950, though it is hard to access comprehensive and accurate data for this period. Figure 3 depicts the ratio of youth dependency for several industrial countries with available age distribution data in the period 1850 to 2150. It confirms that Canada, the United States, and much of Europe were transitioning to lower fertility long before 1950. Youth dependency in the United States, for example, declined from 74 percent in 1850 to 36 percent in 1945, a decline similar to that in other countries. In fact, the degree of comovement across countries is striking, suggesting that long-run fertility trends have been dominated by global events such as world wars and the Great Depression. The one exception to the global fertility decline prior to 1950 is Japan, where youth dependency remained above 60 percent until that year. Unlike the rest of the world, Japan was in a high-fertility equilibrium until the end of World War II, which explains the severity of population aging in Japan today.

## II. The Model

This section describes the open economy OLG model, which is used to simulate the effects of population change on international capital flows. It initially outlines the life cycle problem for the representative agent in economy $j$, which provides the

Figure 3. Youth Dependency Ratios, 1850–2150




basis for the model of large open economies. In this discussion, the index $j$ is hidden for notational convenience. It then develops the open economy model, in which several of these OLG economies differ in total factor productivity (TFP) and population structure, but are identical in all other respects, including preferences and the production technology. These economies are connected at the global level by two equilibrium conditions. The first requires that the rate of return on capital be equalized across economies, which reflects the assumption of perfect capital mobility. The second requires that the global supply of capital equal global demand, which allows saving to diverge from investment within regions over a population shift.

The representative agent in the OLG model lives for four periods: childhood, young working age, old working age, and retirement. In childhood, agents are not active decision makers and rely on their parent, young workers, for consumption $c_t^0$. Young workers have an endowment of one unit of time, of which they devote $\lambda$ units to raising each child, with time not devoted to childrearing inelastically supplied to the labor force. They make a standard consumption-saving decision, setting period $t$ household consumption $c_t^1 + (1+n_t)c_t^0$ and saving $s_t^1$, where $n_t$ denotes exogenous period $t$ cohort growth, which is given by $N_t = (1+n_t)N_{t-1}$, while the age distribution in period $t$ consists of $N_{t-1}$ young workers, $N_{t-2}$ old workers, and $N_{t-3}$ retirees. The budget constraint facing young workers is therefore:

$$(1+n_t)c_t^0 + c_t^1 + s_t^1 = w_t\left[1-\lambda(1+n_t)\right] \tag{1}$$

The link between cohort growth and effective labor supply is important because it allows for a rise in labor force participation rates as fertility declines. This feature captures the fact that declining fertility has been associated with a rise in labor force participation among women in industrial countries, a trend that could spread to developing nations in coming years. In addition, this feature of the model allows for the possibility that the effects from population aging on the capital-labor ratio could be offset by greater labor supply among young adults, the result of lower youth dependency.[8]

In old working age, agents again supply labor inelastically, though they now supply one full unit of labor, their children having become self-sufficient as young workers. Wage income is supplemented by interest on wealth accumulated from the previous period. The constraint of a period $t+1$ old worker is thus

$$c_{t+1}^2 + s_{t+1}^2 = w_{t+1} + \left(1 + r_{t+1}\right)s_t^1. \tag{2}$$

Here $r_{t+1}$ denotes the return on capital held from period $t$ into $t+1$. Retirees no longer supply labor and, there being no bequests, simply consume down their retirement saving. Since this amounts to a decision rule for consumption, retirees—like children—are not active decision makers in the model. The budget constraint for a period $t+2$ retiree is simply

$$c_{t+2}^3 = \left(1 + r_{t+2}\right)s_{t+1}^2. \tag{3}$$

Preferences are described by an additively separable utility function. The discounted lifetime utility of an agent born in period $t-1$ is

$$V_t = \alpha\left(1 + n_t\right)^{1-\varepsilon} \frac{\left(c_t^0\right)^{1-\theta}}{1-\theta} + \frac{\left(c_t^1\right)^{1-\theta}}{1-\theta} + \beta \frac{\left(c_{t+1}^2\right)^{1-\theta}}{1-\theta} + \beta^2 \frac{\left(c_{t+2}^3\right)^{1-\theta}}{1-\theta}. \tag{4}$$

This expression shows that young workers, the parent generation, derive utility from feeding their children. As a result, changes in the age distribution generate youth dependency effects on aggregate saving, in addition to old-age dependency effects. This feature of the model has the advantage that it permits a more accurate depiction of saving behavior over the life cycle. It also allows for the possibility that lower youth dependency from declining fertility, a key feature underlying population aging in many industrial and developing countries, may offset the adverse effects on aggregate saving from having many old people dissave in retirement. The magnitude of the youth dependency effect is determined by $\alpha$ and $\varepsilon$, which control the extent to which parents care for their children. The former parameter determines if parents discount the utility of their children, which is the case for $\alpha < 1$, while the latter implicitly allows for economies of scale in childrearing. This is because the weight per child in the parental utility function is declining in the number of children as long as $\varepsilon > 0$.

Turning to other parameters in the model, the subjective discount factor is given by $\beta$, where $0 < \beta < 1$, while $\theta$ is the coefficient of relative risk aversion, the reciprocal of the intertemporal elasticity of substitution. When $1/\theta$ is greater than

[8]This specification is adopted from Higgins (1994). It assumes that childrearing time rises linearly with the number of children and thus fails to account for the possibility of extensive economies of scale in raising children. Though economies of scale in this regard are captured in the formulation of preferences, the simulation results are of course sensitive to changes in specification. For a more general version of the model and sensitivity analysis with respect to key parameters, see Brooks (2000).

one, higher interest rates lead to increased savings, while the opposite is the case when $1/\theta$ is less than one. When $\theta = 1$, the income and substitution effects of changes in the interest rate cancel out.

Output is generated according to a constant returns to scale neoclassical production function. Factors markets are efficient so that capital and labor are rewarded their marginal products:

$$r_{t+1} = \phi\pi_{t+1}K_t^{\phi-1}L_{t+1}^{1-\phi} - \delta \quad \text{and} \tag{5}$$

$$w_{t+1} = (1-\phi)\pi_{t+1}K_t^{\phi}L_{t+1}^{-\phi}. \tag{6}$$

$L_{t+1} = [1-\lambda(1+n_{t+1})]N_t + N_{t-1}$ represents the aggregate labor supply, adjusting for changes in labor force participation due to changes in cohort growth. $\pi_{t+1}$ is a time-varying productivity parameter, which is calibrated in the open economy setting to match the evolution of income per capita across industrial and developing regions. $\delta$ is the depreciation rate of capital. The capital stock entering period $t+1$ production is dated as of period $t$ because it is generated by saving decisions in period $t$. The optimal consumption profile over the life cycle is given by

$$c_t^0 = (\alpha)^{1/\theta}(1+n_t)^{-\varepsilon/\theta}c_t^1, \tag{7}$$

$$c_t^1 = \Phi_t^{-1}\left[w_t\left[1-\lambda(1+n_t)\right] + \frac{w_{t+1}}{(1+r_{t+1})}\right], \tag{8}$$

$$c_{t+1}^2 = \left[\beta(1+r_{t+1})\right]^{1/\theta}c_t^1, \tag{9}$$

$$c_{t+2}^3 = \left[\beta^2(1+r_{t+1})(1+r_{t+2})\right]^{1/\theta}c_t^1, \quad \text{and} \tag{10}$$

$$\Phi_t = 1 + (\alpha)^{1/\theta}(1+n_t)^{\frac{\theta-\varepsilon}{\theta}} + \frac{\left[\beta(1+r_{t+1})\right]^{1/\theta}}{(1+r_{t+1})} + \frac{\left[\beta^2(1+r_{t+1})(1+r_{t+2})\right]^{1/\theta}}{(1+r_{t+1})(1+r_{t+2})}. \tag{11}$$

Equation (7) shows that an increase in the number of children leads to a fall in consumption per child relative to consumption of young workers. However, it can be shown that for $\theta > \varepsilon$, consumption of the child cohort relative to that of young workers is increasing in $n_t$.

Turning to the open economy model, the world is assumed to consist of $m$ regions, which are allowed to differ in the evolution of their age distributions and TFP levels, but are identical in all other respects. The TFP parameter will be used below to calibrate these economies so that they match historical data on income per capita across industrial and less-developed regions of the world. It effectively permits regions to vary in size and therefore in their impact on the global return on capital. Regions with a low TFP parameter look like small open economies, taking the return on capital as essentially given, while countries with high TFP are larger and behave more like closed economies.

Since capital is assumed to be perfectly mobile, agents in economy $j$ receive the same return whether they invest in domestic or foreign capital:

$$r_{t+1} = \phi\pi^j_{t+1}\left(K^j_t\right)^{\phi-1}\left(L^j_{t+1}\right)^{1-\phi} - \delta = \phi\pi^i_{t+1}\left(K^i_t\right)^{\phi-1}\left(L^i_{t+1}\right)^{1-\phi} - \delta. \tag{12}$$

This no-arbitrage condition implies a relationship between the capital stock in region $j$ and region $i$ that must hold in equilibrium:

$$K^i_t = \left[\frac{\pi^i_{t+1}}{\pi^j_{t+1}}\right]^{\frac{1}{1-\phi}}\left[\frac{L^i_{t+1}}{L^j_{t+1}}\right]K^j_t. \tag{13}$$

It can also be shown that wage income across regions is related by a factor measuring relative productivity:

$$w^i_{t+1} = \left[\frac{\pi^i_{t+1}}{\pi^j_{t+1}}\right]^{\frac{1}{1-\phi}} w^j_{t+1}. \tag{14}$$

The restriction that the production technology is identical across regions has the unfortunate implication that the capital-output ratios are restricted to be equal across economies. This has obvious disadvantages in calibrating the model to industrial and developing economies but is necessary to keep the model tractable.

Global equilibrium in capital markets requires that global demand for capital equal global supply or, equivalently, that net saving equal net investment for the global economy:

$$\sum_{j=1}^{m} K^j_t = \sum_{j=1}^{m}\left[N^j_{t-1}s^{1j}_t + N^j_{t-2}s^{2j}_t\right]. \tag{15}$$

This condition allows saving and investment to diverge within regions over a demographic shift. When this occurs, capital flows arbitrage away differences across regions in the rate of return on capital, subject to the constraint that saving equals investment at the global level.[9]

## III. Simulating the Effects of Population Change on International Capital Flows

The model is calibrated so that each period represents about 20 years. The subjective discount rate $\beta$ and the discount rate applied to the utility of children $\alpha$ each equal 0.6, which corresponds to an annual discount rate of 0.97. The relative risk aversion parameter $\theta$ is set at 2, while $\varepsilon$ equals 0.5. This implies that, even though

[9]The equilibrium condition in (15) can be rewritten as a nonlinear difference equation in the capital-labor ratio of a numeraire region. The model therefore has just one state variable and is extremely tractable. Brooks (2000) derives this expression and shows that the steady state capital-labor ratio of this numeraire region is independent of relative productivity levels and depends only on factors relating to the numeraire economy. This result also obtains for other level differences, for example, differences in initial population size across economies, which the model accounts for.

consumption per child is declining in cohort growth, consumption of the child cohort relative to that of its parent is increasing in $n_t$. The time cost of childrearing parameter $\lambda$ equals 0.1, so that young workers devote about 10 percent of their time in steady state to raising their children. The share of output rewarded to capital equals 0.3, while depreciation occurs at a rate of 5 percent per year, so that 65 percent of the capital stock is lost each period. Only extremely large changes to this parameterization affect the qualitative implications of the model.[10]

Against this background, this section simulates the effects on international capital flows from changes in the global population structure. It does this by moving the model from a high- to a low-fertility steady state, with regional population dynamics over the transition calibrated to historical and projected data from 1950 to 2150. The imposition of steady states at either end of the simulation is problematical, because this means that population growth across regions must be identical before and after the transition period. Since population growth is assumed to converge toward the end of the simulation, the difficulty is how to impose a steady state prior to the transition. This paper adopts the following approach. Figure 1 suggests that North America, the EU, and the FSU countries had lower fertility levels in 1950 than Japan and developing regions. Figure 3 suggests that this is because the United States and Europe were experiencing a fertility decline long before 1950. To account for this, the paper imposes a high-fertility steady state in 1850, beyond which cohort growth declines in North America, the EU, and the FSU in line with the youth dependency ratios in Figure 3, while it remains broadly unchanged in Japan and other regions.[11]

Figure 4 plots annualized cohort growth across regions for the simulated population shift. In the initial steady state, the world is in a high-fertility equilibrium with cohort growth at 2.7 percent on an annualized basis. The population shift begins in 1870 when cohort growth in North America, the EU, and the FSU falls gradually to around 1 percent in the 1950 period. In the absence of reliable data, cohort growth rates in less-developed regions are extrapolated linearly from 1850 to generate realistic youth dependency ratios in 1950. As a result, cohort growth in Africa and Latin America rises above the initial steady state, while it falls below in China and the ROW region. Cohort growth in Japan remains broadly stable leading up to 1950, a reflection of relatively stable youth dependency during the prewar years.

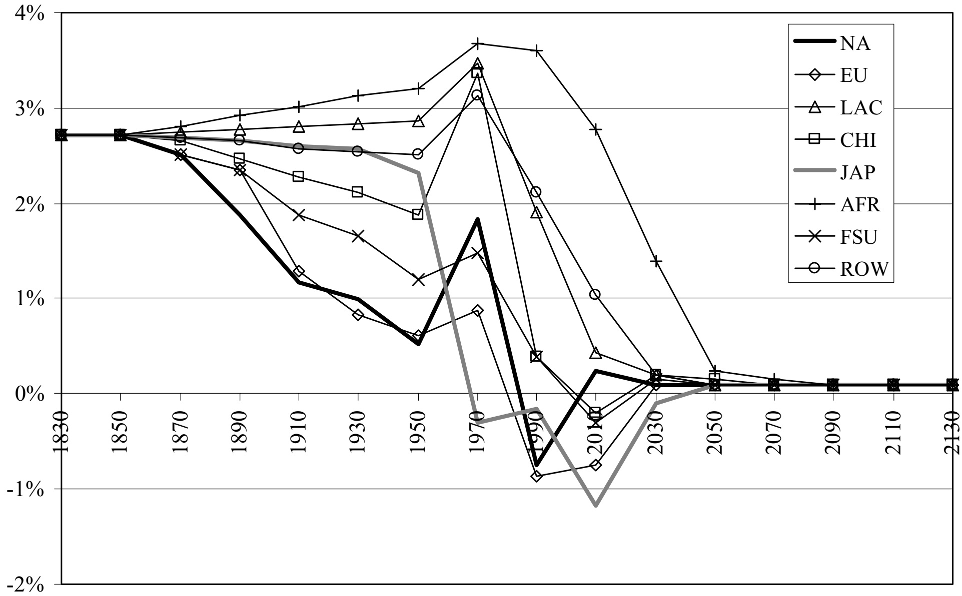
From 1950 on, cohort growth replicates historical and projected population trends, rising in the period around 1970 in North America, the EU, and the FSU because of the baby boom, and falling rapidly thereafter as the postwar baby bust takes hold.[12] In China, Latin America, Africa, and the ROW region, cohort growth is substantially higher and approaches developed country levels only in 2050.

[10]The specification of preferences is similar to that of Higgins (1994) who, in the context of a three-period model, sets the discount factor applied to the utility of children to 0.53, which corresponds to an annualized rate of 0.975. He sets $\lambda$ and $\varepsilon$ equal to 0.1 and 0.5, respectively, and $\phi = 0.33$, $\beta = 0.54$, $\delta = 0.72$, and $\theta = 0.77$.

[11]Only extremely large changes to the level of cohort growth in the initial steady state and along the transitional paths leading up to 1950 have qualitative implications for international capital flows beyond 1990. This suggests that the initial steady state is far enough removed that it does not affect the transitional dynamics during the period of interest.

[12]Cohort growth rates are computed by aggregating the 5-year age groups in the population data into 20-year age groups that span 0–19, 20–39, 40–59, and 60 and over. Cohort growth is calculated by making 20-year centered averages of these 20-year age groups around the years in Figure 4 and deriving the growth rate of the child over the young worker cohort.

Figure 4. Annualized Cohort Growth in Percent over the Simulated Population Shift




Notes: NA = North America; EU = European Union region; LAC = Latin American countries; CHI = People's Republic of China; JAP = Japan; AFR = Africa; FSU = countries of the former Soviet Union; and ROW = the rest of the world.

Japan follows an entirely different path. It transitions from the initial high-fertility equilibrium to zero cohort growth in just one model period, between 1950 and 1970. The population shift ends in 2070 when cohort growth around the world stabilizes at close to zero.

Over this population shift, the TFP parameter is used to control for differences in economic size, both across regions and over time. This is important because the larger an economy, the greater its impact on the global interest rate for a given population transition. The bigger this effect, the closer domestic saving and investment must move together in equilibrium, so that the region will more closely resemble a closed economy. In contrast, the same shock will not affect the world return on capital to the same extent in a smaller economy, so that domestic investment moves more independently from domestic saving over the transition.

In practice, differences in economic size have been important both across regions and over time. Table 1 plots real GDP per capita in percent of that in North America for the regions of the model, using data from the Penn World Tables Mark 5.6 and Maddison (1995).[13] For the EU region, income per capita in 1890 was 70 percent of that in North America, before falling steadily to 42 percent in 1950. Income per capita in Japan was only 28 percent of that in North America in 1890 and fell to 16 percent during the World War II period. It subsequently recovered

[13]The data from Maddison (1995) give GDP per capita in 1985 U.S. dollars and the total population for a range of countries starting in 1870. This data is reproduced in Barro and Sala-i-Martin (1995). For the AFR and FSU economies, the POP series, which is population in thousands, and the RGDPCH series, which is GDP per capita in constant dollars, were used from the Penn World Tables Mark 5.6 to construct these ratios.

Table 1. Real GDP Per Capita in Percent of North America

| | European Union | Latin America | China | Japan | Africa | Former Soviet Union | Rest of World |
|---|---|---|---|---|---|---|---|
| 1870 | 77 | ... | ... | ... | ... | ... | ... |
| 1890 | 70 | 21 | 13 | 28 | ... | ... | 15 |
| 1910 | 60 | 19 | 9 | 24 | ... | ... | 12 |
| 1930 | 60 | 20 | 7 | 28 | ... | ... | 9 |
| 1950 | 42 | 16 | 4 | 16 | 8 | 25 | 7 |
| 1970 | 64 | 21 | 6 | 57 | 8 | 32 | 7 |
| 1990 | 70 | 17 | 10 | 79 | 8 | 42 | 7 |

much more sharply than the EU, reaching 79 percent in 1990. In contrast, GDP per capita in Africa, China, Latin America, and other less-developed regions has been much more stable relative to that in North America.

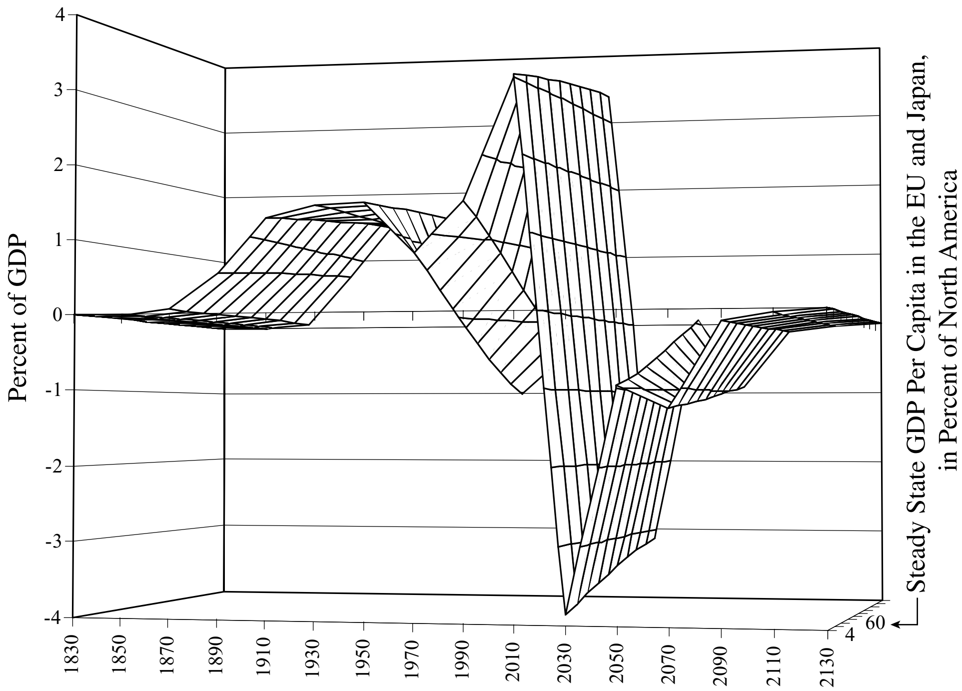
Two approaches are used to account for these differences in size and how they interact with the population shift. The first allows the TFP parameters to differ across regions, but not over time. This amounts to a "partial equilibrium" analysis of the population shift, because it holds everything but demographics constant. But because real incomes in the EU region and Japan have converged substantially toward those in North America since 1950, it is unclear where to set the productivity parameters of both regions over the simulation. This is addressed by simulating the population shift ten times, progressively raising the productivity parameters assigned to the EU and Japan from 0.1 to 1 in increments of 0.1. The other TFP parameters are fixed such that the steady state GDP per capita ratios are 21 percent for Latin America; 10 percent for China, Africa, and the ROW region; and 25 percent for the FSU area. In effect, this approach amounts to a sensitivity analysis that examines if the effects of the population shift are robust to variation in size of the EU and Japan relative to North America.

The second approach allows the productivity parameters to vary across regions and over time. They are calibrated to match exactly the ratios of GDP per capita in Table 1. In effect, this approach accounts for the fact that, over the simulation period, the EU region and Japan changed from relatively large to small economies and back again. The impact of population dynamics in both regions on the global economy will therefore have changed over time. In addition, because changes in regional TFP levels affect the implicit return on capital across regions, they will directly affect international capital flows. For example, economic recovery in the EU and Japan after World War II will raise their implicit returns on capital, causing them to attract capital from the rest of the world and run large current account deficits.

Figure 5 depicts the current account in percent of GDP for North America, using the first approach to simulate the effects of the population shift on international capital flows.[14] It is three-dimensional because it simulates the same

[14]The nonlinear difference equation in the capital-labor ratio of the numeraire region is used to solve for the steady state capital-labor ratio for given cohort growth. Using *csolve.m,* a nonlinear equation solver for *Matlab* written by Christopher Sims, this is done for the pre- and post-transition steady states. These capital-labor ratios are then imposed as initial and terminal conditions in a system of nonlinear difference equations that must hold over the transition. The equilibrium path of the capital-labor ratio consistent with this system of equations is then solved for numerically using *csolve.m*.

Figure 5. The Simulated Current Account Balance in North America
*(In percent of GDP)*




population shift ten times, raising the TFP parameters for the EU region and Japan progressively from 0.1 to 1 in increments of 0.1.[15] Along the three-dimensional axis, it plots the steady state ratios of GDP per capita in the EU and Japan, as their TFP parameters rise away from 0.1 in both regions.

Figure 5 shows that, as cohort growth in North America falls below the global average after 1850, the underlying return on capital in the region falls, which generates substantial capital outflows through 1950. In the 1970 period, the postwar baby boom in North America drives cohort growth above that in the EU, Japan, and the FSU countries. This raises the underlying return on capital in North America, so that for low TFP parameters in the EU and Japan, the current account surplus shrinks. But as TFP in the EU region and Japan rise above 0.4, North America begins to import capital in 1970. In fact, the North American current account ranges from a surplus of 0.8 percent of GDP for a TFP parameter of 0.1

[15]The current account balance is derived as the difference between net saving and net investment. Net saving in period $t$ is given by $A_t - A_{t-1}$ where $A_t = N_{t-1}s_t^1 + N_{t-2}s_t^2$ is wealth accumulated in period $t$ and invested in period $t+1$. If $A_t - A_{t-1} > 0$, total saving by workers exceeds dissaving by retirees, while if $A_t - A_{t-1} < 0$ total dissaving by retirees exceeds wealth accumulated by working-age cohorts. Net investment in period $t$ is given by $K_t - K_{t-1}$. In the steady state it is the case that $A_t - A_{t-1} = K_t - K_{t-1}$. Net saving equals net investment just as in a closed economy. Over the transition, however, as cohort growth diverges across regions, this need no longer be the case. Regions with net saving above net investment are investing abroad and accumulating foreign assets, while the reverse is true for regions with net saving below net investment.

in the EU and Japan to a deficit of –1 percent when $\pi = 1$ in both regions. The intuition behind this result is simple. Cohort growth in the EU and Japan is below that in North America, so that as $\pi$ increases, they have a stronger impact on the world return on capital and drag it down.

The North American current account peaks in 2010 at around 3.4 percent of GDP, holding the GDP per capita ratio for the EU and Japan constant at 73 percent or $\pi = 0.8$, then drops sharply to –3.2 percent of GDP in 2030 before returning to zero in the long-run steady state. The intuition behind this sharp change is simple. A large cohort of baby boomers is born in 1970. The boomers accumulate savings for retirement primarily in 2010 when they are in old working age. This drives saving above investment, causing the current account surplus. They dissave in 2030 when they are in retirement, driving the current account negative.

Figure 6 plots the current account balance in percent of GDP for the EU area, which, as in North America, turns positive after 1850 as cohort growth in Europe falls below the global average. With the rise in cohort growth in the 1970 period, the surplus declines because the underlying return on capital in the region rises toward the world interest rate. In fact, as TFP rises from 0.1 to 1, the surplus declines from 1.6 percent of GDP to zero, because the global return on capital is driven to a greater extent by cohort growth in the EU. The current account peaks in 2010 with a surplus of 2.7 percent, assuming that steady state GDP per capita is 73 percent of that in North America, and then switches to a deficit of 2.9 percent of GDP in 2030, followed by a deficit of 3.1 percent in 2050. This switch stems from the fact that, as in North America, working-age baby boomers are saving for retirement in 2010, which pushes up domestic saving supply relative to investment demand. The fact that the current account deficit worsens from 2030 to 2050 is linked to the evolution of cohort growth in the EU, which unlike North America, remains negative in 2010. As in North America, the transition from surplus to deficit between 2010 and 2030 is robust to different values for $\pi$.

Figure 7 plots the current account balance in percent of GDP for Japan. As cohort growth in North America, the EU, and the FSU countries declines after 1850, the underlying return on capital in Japan rises above the global return, causing capital inflows. In 1970, cohort growth in Japan falls from an annualized rate of 2.3 percent in 1950 to –0.3 percent. This collapse in fertility dramatically reduces the implicit return on capital, so that Japanese savers shift their holdings abroad, which produces a massive current account surplus in 1970. The size of this surplus falls as TFP in Japan increases, because the global return on capital gets pulled down toward its implicit rate of return. With a steady state ratio of GDP per capita of 73 percent, the current account surplus in 1970 amounts to 3.1 percent. For the same TFP parameter, this surplus rises further to 4.7 percent of GDP in 1990, driven by the saving of the last cohort born during the high-fertility equilibrium in 1950. Their dissaving drives the current account balance negative in 2010, when it falls to –0.8 percent of output for a GDP per capita ratio of 73 percent. Japan will suffer a second baby bust when cohort growth falls below –1 percent per year in 2010. This decline in fertility will cause a projected current account deficit of 4.4 percent of GDP in 2050, when a large cohort born in 1990 moves into retirement.

Figure 6. The Simulated Current Account Balance in the EU Region
*(In percent of GDP)*

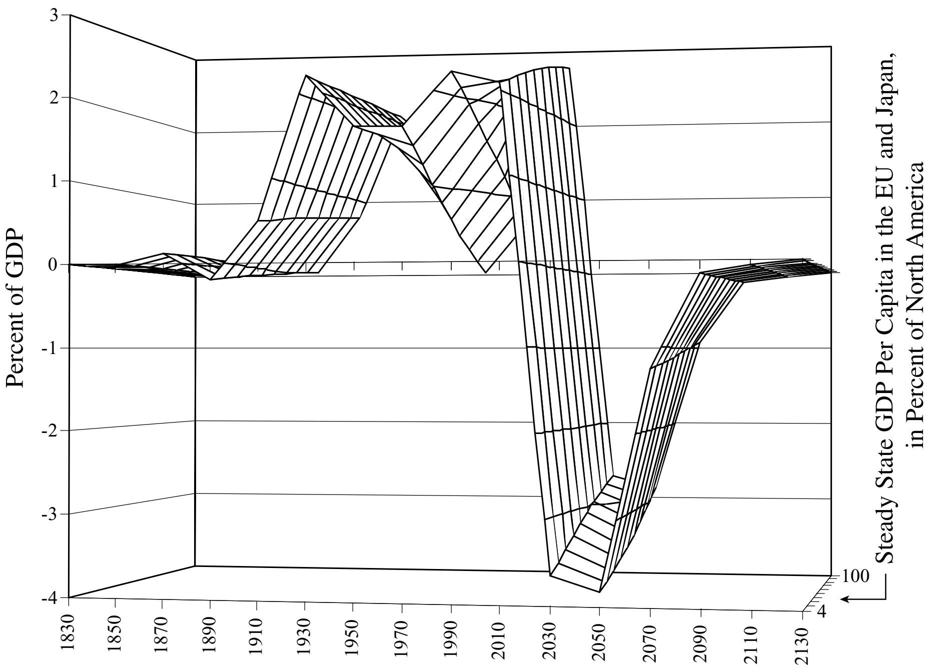
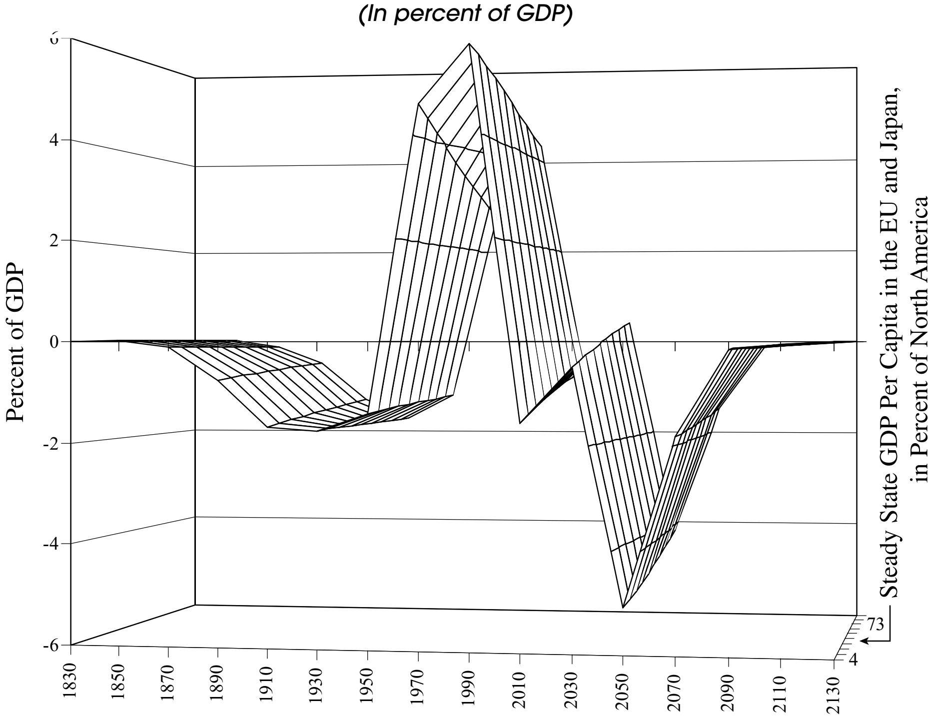



Figure 7. The Simulated Current Account Balance in Japan
*(In percent of GDP)*



The effects of the population shift on developing regions are a mirror image of those on the industrial economies. The simulation results suggest that Latin America remains dependent on foreign capital through 1990, when the current account registers a deficit of 3.4 percent of GDP, with an assumed ratio of GDP per capita in the EU and Japan of 73 percent in steady state. It switches to exporting capital in 2010, with a surplus of 1.2 percent, which increases to 2.8 percent in 2030. Africa remains dependent on capital imports longer, a reflection of the fact that its cohort growth is far above anywhere else in the world. It is projected to register current account deficits up to 2030, beyond which point it becomes a capital exporter. The population shift in China generates substantial capital imports in 1970 and 1990, amounting to 3.5 and 1.2 percent of GDP, respectively, before the country switches to current account surpluses, starting with a surplus of 4.6 percent of GDP in 2010. Overall, the pattern in the developing economies is of initial dependence on foreign capital, followed by large capital exports toward the end of the transition. This switch is a reflection of population trends in industrial regions, where aging populations consume down their wealth, which includes foreign assets, in retirement.

This "partial equilibrium" approach has the disadvantage that it fails to capture how Japan and the EU have transitioned from relatively large to small economies and back again over the simulation period. As a result, it ignores how changes in economic size can interact with demographic change, hinted at in the three-dimensional charts above. In addition, changes in the regional TFP levels affect implicit returns on capital across regions and therefore impact international capital flows directly. In what follows, this section calibrates the productivity parameters so that, over the demographic shift, the GDP per capita ratios of the EU and Japan in Table 1 are matched exactly through 1990, beyond which it assumes that convergence in the production technology with North America is achieved by 2010 in Japan and by 2050 in the EU. As before, the other TFP parameters are fixed such that the steady state GDP per capita ratios are 21 percent for Latin America; 10 percent for China, Africa, and the ROW region; and 25 percent for the FSU area.

Table 2 shows the current account balances in percent of GDP over the population shift, for this second approach. Both the EU region and Japan now experience large current account deficits in the 1950 period. This is because the postwar recovery in both regions is financed by capital flows from North America and, less realistically, from developing regions where the implicit return on capital, driven only by cohort growth, falls behind the underlying rates of return in Europe and Japan. As Table 2 shows, the EU current account registers a deficit of –2.3 percent of GDP in the 1950 period, a surplus of 0.5 percent in 1970, and a surplus of 0.7 percent in 1990. In the 2010 period, the current account surplus rises to 1.5 percent of GDP, as aging baby boomers accumulate retirement wealth. In 2030, these baby boomers dissave in retirement and the current account registers a deficit of –1.5 percent of GDP. The deficit persists into 2050, when it measures –1.1 percent of GDP. Accounting for the post–World War II recovery therefore leaves the effects of the population shift on the EU area current account qualitatively unchanged. The region still switches from capital exporter to importer between 2010 and 2030.

Table 2. Simulated Current Account Balances in Percent of GDP

| | 1910 | 1930 | 1950 | 1970 | 1990 | 2010 | 2030 | 2050 | 2070 |
|---|---|---|---|---|---|---|---|---|---|
| European Union | 0.70 | 3.67 | –2.27 | 0.50 | 0.74 | 1.53 | –1.52 | –1.13 | –0.38 |
| Japan | –3.00 | 3.77 | –17.28 | –1.30 | 3.68 | 2.63 | 2.16 | –4.02 | –1.48 |
| North America | 1.51 | –0.23 | 3.86 | 1.37 | –0.48 | 2.11 | –3.83 | –0.01 | –0.93 |
| Former Soviet Union | –0.08 | –1.69 | 3.88 | 2.49 | –0.25 | 0.48 | –0.03 | –1.53 | –0.80 |
| Latin America | –1.86 | –4.92 | 1.95 | –0.83 | –2.43 | –0.17 | 2.08 | 0.32 | –0.67 |
| China | –0.70 | –2.97 | 3.46 | –0.45 | –0.83 | 3.33 | –0.23 | –1.38 | –0.73 |
| Africa | –2.34 | –5.74 | 1.32 | –1.02 | –5.83 | –8.59 | –2.20 | 2.20 | 1.77 |
| Rest of World | –1.36 | –4.01 | 2.49 | –0.01 | –2.74 | –2.09 | 1.51 | 1.64 | –0.67 |

The same applies to the projections for North America, which still imply a current account surplus in 2010 and a deficit in 2030. For Japan, however, using TFP to account for changes in real incomes over time has a big effect on the projected current account. This is because the postwar recovery is so strong that the simulation generates a large current account deficit of –17.3 percent of GDP in 1950. Massive inflows are needed to keep the return on capital in Japan, driven up by the rising TFP parameter, in line with the world interest rate. Because these inflows are so large, they change the subsequent path of the Japanese current account. In order to pay off its foreign liabilities, the current account switches to surplus in 1990 and stays positive through 2030. The effects of the postwar recovery in Japan on capital flows are therefore so large that they overpower the medium-term implications of population aging for the current account. In the long run, however, they do not change the fact that demographic forces will cause Japan to become a substantial capital importer. The current account is still projected to register a deficit of 4 percent in 2050 and a deficit of 1.5 percent in 2070.

The simulation results also confirm that, even controlling for the changing economic fortunes of Europe and Japan, high fertility in developing regions has caused them to import capital in the past decades. In Latin America, the resulting higher implicit return on capital generates a current account deficit of 0.8 percent of GDP in 1970 and a deficit of 2.4 percent in 1990. It generates more modest deficits of 0.4 percent in 1970 and 0.8 percent in 1990 for China, but a much larger dependence on external capital in Africa, where the current account in 1990 is simulated to register a deficit of almost 6 percent. Looking forward, the simulation confirms that demographic forces will cause less-developed economies to become capital exporters in the years ahead, though the order in which they do so changes from the “partial equilibrium” setting. China is projected to switch to exporting capital first, registering a current account surplus of 3.3 percent in 2010. Meanwhile, Latin America is forecast to continue importing capital, albeit at a much more modest pace, in 2010. It only switches to exporting capital in 2030, when the region registers a current account surplus of 2.1 percent. Africa is projected to remain dependent on capital imports for the foreseeable future, though its current account deficits in the 2010 and 2030 periods now exceed those in the static exercise.

In some cases, these simulation results are remarkably close to reality. Table 2 shows that this is the case for Latin America, where the simulation generates an average current account deficit over the past 20 years that is very close to the actual deficit of 2.3 percent of GDP, an indication that the region's dependence on external capital is in line with past differentials in productivity and population growth. In contrast, the current account deficit for all of Africa measured 3.4 percent over the past 20 years, substantially below the simulated deficit for the region, a possible sign that factors omitted by the model, such as economic and political risk, have constrained capital flows to the region below levels consistent with its high fertility. A similar conclusion may apply to Japan, where the model yields an average current account surplus over the past 20 years of 3.7 percent of GDP. Compared with an actual surplus of 2.4 percent, this could be seen as evidence that Japan has been kept from exporting capital to an extent consistent with its long-run fundamentals. Turning to North America, the model yields an average current account deficit of 0.5 percent of GDP for the past 20 years. Compared to an actual deficit of 1.9 percent, this is strong evidence that the current account deficit of the United States is substantially out of line with long-run demographic trends.

These conclusions are subject to two important caveats. First, as the example of the postwar recovery in Japan illustrates, the direct effect on international capital flows from convergence in real incomes can be very large. Since the model focuses on long time horizons, GDP per capita in China and other emerging markets could converge with that in North America in two or three model periods, that is, in the next 40 to 60 years. This could alter the projected pattern of capital flows dramatically. Second, although the TFP parameters are basically held fixed for the forecasting segment of the simulation, the effects of past changes in productivity are nonetheless significant for projected capital flows. After all, the reason that the Japanese current account is projected to remain in surplus, even though its population is aging faster than anywhere else, is because it must make good on borrowing that financed its postwar recovery. In a setting with capital market frictions, which would limit the scale of the deficit in 1970, the Japanese current account might be projected to fall into deficit sooner.

## IV. Conclusion

This paper finds that differences in population trends around the world are an important determinant of international capital flows. They explain the emergence as capital exporters of the European Union countries and Japan, where population aging has driven up saving relative to investment in the course of the postwar period; the decline in the current account balance of North America toward deficits, a sign that population aging is relatively less pronounced than in Europe and Japan; and the persistent dependence on foreign capital in Africa, Latin America, and emerging Asia, where population growth has been much higher.

The results also suggest that the aging of the baby boom generation will drive up saving relative to investment in both the EU and the United States in coming years, causing both regions to export large amounts of capital to Africa, Latin America, and other developing countries. Beyond 2020, however, dissaving by the baby boomers in retirement will be associated with large current account deficits in both regions. This shift will be financed by capital flows from Latin America and other emerging markets, though Africa will remain dependent on foreign capital because of continued high population growth. Despite the most severe record of population aging, the simulations suggest that Japan will remain a large exporter of capital until about 2040, though at a declining rate. This is because the model generates large current account deficits for Japan in the 1950s and 1960s, a reflection of its rapid postwar recovery, and predicts that this borrowing will be repaid through future current account surpluses.

At its most basic level, this paper models international capital flows as a function of two key long-run fundamentals: demographics and productivity growth. It thus addresses whether the dependence of many less-developed economies on foreign borrowing is consistent with long-run fundamentals or not. In the case of Latin America, it finds that the current account deficit over the past 20 years is consistent with historical population and productivity growth rates. It therefore raises a question mark over claims that the persistent current account deficits in the region are unsustainable. In fact, the model suggests that some emerging markets, notably countries in Africa, are constrained from importing sufficient capital, though this could be a reflection of factors that the model ignores, such as political and institutional risk.

Among developed economies, the model suggests that Japan has been constrained in its ability to export capital in line with its rapidly aging population. This result is consistent with claims that it has been prevented from exporting its way out of the current recession by trade barriers and implicit political threats from the United States and Europe. The model generates an average current account deficit of 0.5 percent of GDP for North America over the past 20 years. Relative to an actual deficit of 1.9 percent, this is strong evidence that the current account deficit of the United States is substantially out of line with long-run fundamentals.

Although this paper does not directly address the ongoing debate over reforming public pension systems, this debate is an important motivation nonetheless. Since the model does not include a pay-as-you-go pension system in any of its economies, it can be seen as a world in which these systems have been fully privatized. In such a setting, it shows that, even in the absence of the transitional issues in debate over social security reform, projected population trends have important open economy effects, which have been largely ignored in the debate on pension reform.

## REFERENCES

Attanasio, Orazio, and Giovanni Violante, 2000, “The Demographic Transition in Closed and Open Economies: A Tale of Two Regions,” IADB Working Paper No. 412 (Washington: Inter-American Development Bank).

Auerbach, Alan, and Laurence Kotlikoff, 1987, *Dynamic Fiscal Policy* (Cambridge: Cambridge University Press).

Barro, Robert, and Xavier Sala-i-Martin, 1995, *Economic Growth* (New York: McGraw-Hill).

Börsch-Supan, Axel, Alexander Ludwig, and Joachim Winter, 2001, “Aging and International Capital Flows,” NBER Working Paper No. 8553 (Cambridge, Massachusetts: National Bureau of Economic Research).

Brooks, Robin, 2000, "Population Aging and Global Capital Flows in a Parallel Universe," IMF Working Paper 00/151 (Washington: International Monetary Fund).

———, 2002, "Asset Market Effects of the Baby Boom and Social Security Reform," *American Economic Review, Papers and Proceedings*, Vol. 92, No. 2 (May), pp. 402–6.

Diamond, Peter, 1965, "National Debt in a Neoclassical Growth Model," *American Economic Review*, Vol. 55, No. 5 (December), pp. 1126–50.

Higgins, Matthew, 1994, "The Demographic Determinants of Savings, Investment, and International Capital Flows" (Ph.D. dissertation; Cambridge, Massachusetts: Harvard University).

———, 1998, "Demography, National Savings and International Capital Flows," *International Economic Review*, Vol. 39 (May), pp. 343–69.

———, and Jeffrey Williamson, 1996, "Asian Demography and Foreign Capital Dependence," NBER Working Paper No. 5560 (Cambridge, Massachusetts: National Bureau of Economic Research).

Kotlikoff, Laurence, Kent Smetters, and Jan Walliser, 2001, "Finding a Way Out of America's Demographic Dilemma," NBER Working Paper No. 8258 (Cambridge, Massachusetts: National Bureau of Economic Research).

Lucas, Robert E., Jr., 1990, "Why Doesn't Capital Flow from Rich to Poor Countries?" *American Economic Review*, Vol. 80 (May), pp. 92–96.

Maddison, Angus, 1995, *Monitoring the World Economy: 1820–1992* (Washington: Organization for Economic Cooperation and Development).

Sachs, Jeffrey, 2001, "The Benefits of a Weaker Yen," *Financial Times*, April 17.